

Experimental Machines for Autodibble Planting

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PHYSICALLY weak seedlings such as carrot, lettuce, onion, and beet may fail to emerge because of premature soil drying, accumulation of salts in the shallow seedbeds, or from not being able to break through even weak soil crusts. To insure adequate stands of these crops, excess seed is often planted which later requires time-consuming and expensive thinning. Precision planting methods that eliminate hand labor and thinning are needed. Any such method must insure a consistently high emergence of seedlings under the variety of microclimate and soil conditions which are encountered from year to year during the planting period.

One solution to some of the problems encountered in precision planting is suggested by the punch or dibble plant method (Cary 1967). Individual seeds are dropped in small holes and left uncovered. Because of the natural soil temperature gradients during the day, the air in the hole remains reasonably stable and the soil does not dry out. This allows the seed to germinate and send its growing tip to the surface without resistance from soil particles. Seeds that are normally planted 0.25 to 0.5 in. (6* to 12 mm) deep in a conventional seedbed may be planted 1.5 or 2 in. (38 to 50 mm) deep in holes 0.3 in. (8 mm) in diameter. Planting in relatively deep open holes places the seeds below the zone of high salt accumulation at the surface and at soil depths where moisture conditions remain optimum for seed germination for a longer period. Hand-planted sugar beets using the open hole method have grown well under field conditions in Idaho and in the Imperial Valley of southern California (Cary 1968; Mayland and Cary 1968; Robinson and Worker 1969).

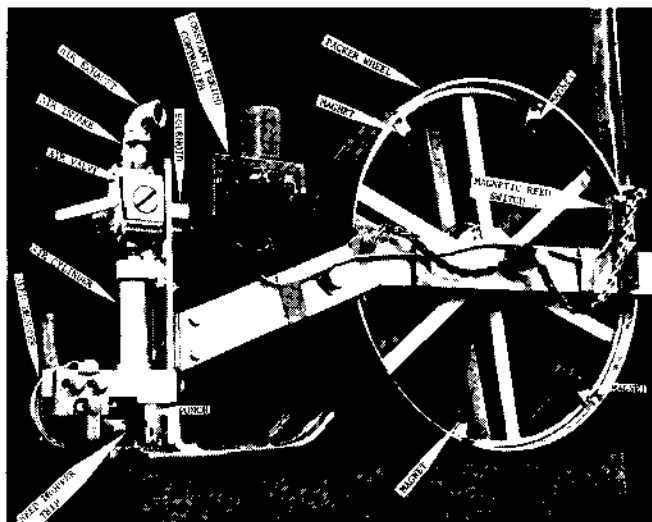


FIG. 1 Pneumatic punch machine which places individual coated seeds in precisely spaced holes in the seedbed.

Because of the encouraging preliminary results with punch planting, two types of machines were developed. Their operation is described with suggestions for further development.

PNEUMATIC PUNCH MACHINE

The pneumatic planter, Fig. 1, uses a 16-in. (40-cm) diameter by 4-in. (10 cm) wide packing wheel. Magnets attached to the wheel actuate a reed switch circuit (Fig. 2) that opens the air valve, forcing the pneumatic cylinder to punch a hole in the soil. The spacing of magnets on the packing wheel controls

The seed dropper (Fig. 3) has a vertical rotating wheel with slots, which hold one seed at a time. As the wheel rotates, single seeds are carried over the top against a nonrotating, seed-retaining ring. The ring has an opening to deliver the seed to the spout, which in turn directs it into the hole in the soil. The slotted wheel is moved one notch at a time by a ratchet, which is engaged by the soil punch.* The seed-drop mechanism is built for 9/64-in. (3.5-mm) diameter spheres. Any small seed can be pelleted to this size.†

There are several adjustments on the

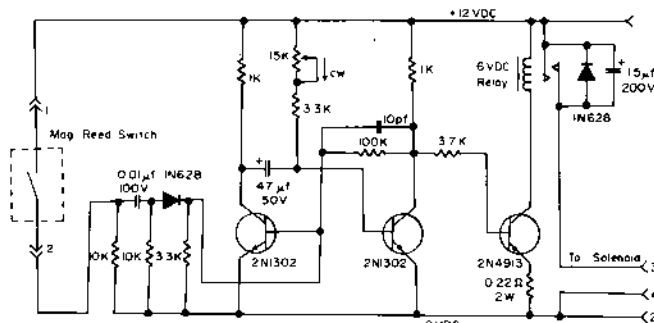


FIG. 2 Circuit used for controlling the air valve in Fig. 1.

the seed spacing. As the punch goes into the soil, it actuates the seed dropper, which delivers a seed over the hole as the cylinder makes its return stroke. The punch is returned to the "up" position by an internal spring in the air cylinder.

*The seed delivery system is a simplification of that designed by Winslow Pacific, Inc.,† Carlsbad, Calif.

†German's, Inc., ‡ Fresno, Calif. private communication.

†Trade names and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment of the product listed by the U. S. Department of Agriculture.

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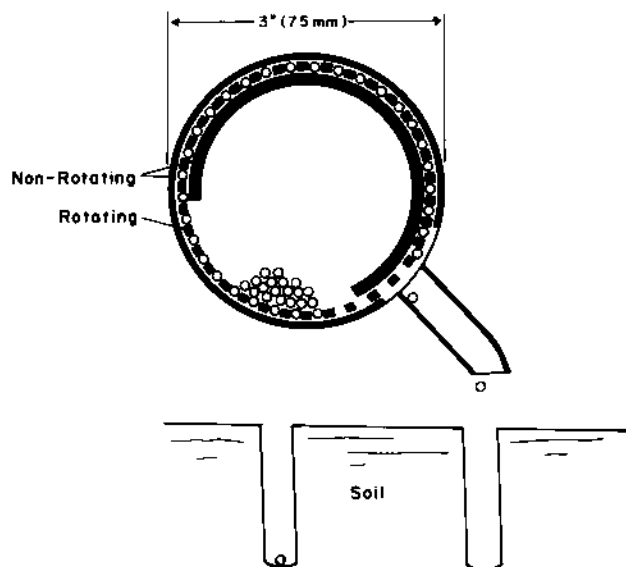


FIG. 3 Diagram of the seed drop mechanism used to deliver single seeds for individually punched holes in the seedbed.

planter for matching seed delivery time to tractor speed. The constant period controller is adjustable to regulate the time the solenoid-operated air valve remains open. The distance between the seed dropper and the soil punch can be adjusted to synchronize seed delivery with ground speed. The seed dropper may also be rotated with respect to the ratchet linkage to change the seed trajectory.

The planter was tested late in the fall of 1971 by attaching it to the rear of a strip-type rototilling incorporator. The rototillers on the incorporator were set to till a 12-in. (30-cm) wide strip directly ahead of the planter. This left the soil uniformly moist, which is essential if the packing wheel is to provide a stable surface and a firm seedbed. The punch was operated from a cylinder of compressed air with the pressure regulator set at 60 psi (4.3 kg per cu cm). A tractor groundspeed of 1 mph (0.45 m per sec) was satisfactory for the planter. Uniform groundspeed is a critical factor in delivering the seed over the hole at the proper time.

The machine was adjusted to make holes 1.5 in. (38 mm) deep, 0.3 in. (8 mm) wide, and 0.5 in. (13 mm) long. Several rows of sugarbeets were planted; 85 percent of the holes received a seed; 15 percent either missed the hole or the dropper failed to release a seed. After accounting for seed lot viability, the emergence of properly planted seeds was near 50 percent. The low emergence resulted from several rain showers that filled in some of the holes and covered the seedlings, however this problem can be overcome as described in a following section on greenhouse tests.

BELT-TYPE PLANTER

The belt-type machine is sketched in Fig. 4. A belt is riveted to brackets brazed to the sides of two chains, which in turn run on pairs of sprocket wheels at each end of the planter. The soil punches are mounted between the front pair of sprocket wheels. The belt contains eyelets spaced at exactly the same distance as the punches on the front wheel. The punches, mounted on shafts suspended between the sprocket wheels, rotate through an arc of about 120 deg. A coil spring mounted on each shaft holds the punch in the proper position to engage the eyelets in the belt as the planter rolls forward. When the punch enters the soil, the eyelet in the belt holds it in one position at the soil surface while the base of the punch rotates. This makes a slightly "bell-shaped" hole in the soil which should hold the soil moisture longer than the "slot" shape produced by the pneumatic planter. As the punch rises out of the eyelet in the belt, the spring on its shaft returns it to the proper position to engage with the next eyelet.

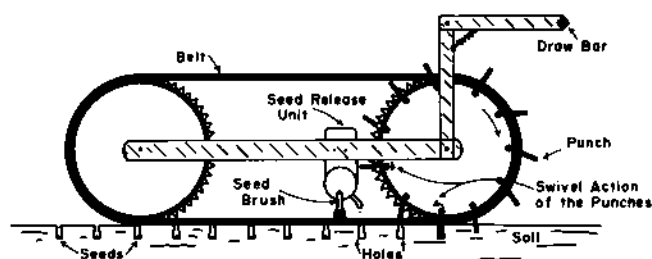


FIG. 4 Diagram of the belt planter developed to form precise holes in the seedbed and deliver single seeds to each.

A single seed-drop mechanism similar to that described in the previous section is actuated by the punch carriers on the front wheel. A seed drops onto the belt as each punch is removed from the belt eyelet. The seed is then brushed along the belt until it falls through the eyelet, which remains over the hole in the seedbed.

This unit also requires a uniformly moist soil that can be packed into a firm, stable surface and seedbed. It can be mounted on a toolbar behind a strip-type incorporator and bed shaper. Guards must be used so that loose soil does not tumble onto the belt.

One difficulty that may be encountered with this type of planter is a tendency of the belt to creep with respect to the soil surface. If this occurs as the brush delivers the seed to the eyelet, the eyelet may no longer be directly aligned over the hole in the soil.

GREENHOUSE SEEDBED TESTS

If the dibble system of planting is to be successful, the soil around the hole must be stable. If the hole fills with soil, the seedling may never emerge. Having the soil moist on the surface and then compressing it with a packing wheel just before the punch arrives is the first step in forming a stable hole. However, since rain may still wash soil into some holes, a greenhouse study was initiated to test the feasibility of further stabilizing the soil surface. A replicated experiment compared normal planting (0.5 in., or 13 mm deep) and punch planting (1.5 in. or 38 mm deep) plus five different soil surface stabilization treatments, Table 1. The moist soil surface was packed with a press wheel, and holes were punched with a pencil. A single pelleted sugarbeet seed was dropped in each hole, and a 3-in. (7.5 cm) wide band of the stabilizer was sprayed on the surface at the rates listed in column 3, Table 1. The polyvinyl chloride, Portland cement, and CohereX were diluted five parts to one by weight with

TABLE 1. RESULTS OF GREENHOUSE SUGARBEET TEST PLANTINGS. DIFFERENCES IN EMERGENCE BETWEEN TREATMENTS OF 15 PERCENT OR MORE MAY BE CONSIDERED STATISTICALLY SIGNIFICANT

Treatment	Percent emergence		Approximate amount of material	Approximate additional cost for material per acre
	Flat surface	Rounded surface		
Normal	33	20	—	None
Hole without stabilizer	15	59	—	None
Asphalt mulch, around the hole	61	84	210 lb per hectare	\$30.00
Polyvinyl chloride, around the hole	70	82	230 lb per hectare	\$30.00
Portland cement, around the hole	50	70	220 kg per hectare	\$ 4.00
Cohex, around the hole	47	—	12 lb per hectare	\$ 5.00
H ₃ PO ₄ , around the hole	—	82	16 lb per hectare	None

water while the asphalt and H₃PO₄ were diluted three parts to one. Separate germination tests were made to check each of these materials for seedling toxicity and none was found. Many other soil stabilizing additives are also available (Armbrust and Dickerson, 1971).

As soon as the soil surface had dried after planting, a rainstorm was simulated by adding approximately 1.0 in. (2.5 cm) of water by sprinkling from a height of 3 ft (90 cm). The water was added within a 30-min period so that the soil's natural intake rate was exceeded and some ponding occurred on the surface. Evaporation conditions were adjusted using lights and a fan to evaporate at first 0.5 in. (12 mm), and later 0.2 in. (5 mm) of water per day from a free water surface.

The percent emergence is shown in Table 1, column 1. Since there was a tendency of the ponded water to wash soil from the unstabilized areas into the holes in the treated bands, a second trial was made in which the seed row was shaped into a convex crown approximately 0.5 in. (1.2 cm) high. In this experiment, 1.0 in. (2.5 cm) of rain was simulated as soon as the soil surface dried, followed by a second in. (2.5 cm) 1 wk later. The increased severity of the second treatment compared to the first is emphasized by the decreased emergence from the normal check due to a thicker soil crust, while the holes with the unstabilized surface showed a significant improvement due to the convex surface. Since germination of the seed lot was 85 percent, the stabilized seed row treatments with the convex surface had near-perfect emergence with the exception of cement.

All of the first four surface additives listed in Table 1 were about equal in stabilizing the soil surface. Phosphoric acid did not form as hard a surface, but has the advantage of acting as a fertilizer and so does not increase costs (Robbins et al 1972). The superior performance

of the convex seed row compared to the flat surface was also demonstrated by simulating rain with water drops released from a height of 12 ft (3.6 meters) above the soil surface.

CONCLUSIONS AND SUGGESTIONS FOR FURTHER DEVELOPMENT

A reasonable objective for additional work is to develop a one-operation system for seedbed shaping, herbicide incorporation, and planting. An optimum seed row shape might be that shown in Fig. 5. Such a seed row could be used in a 2-row bed formed by strip-type incorporators and the planters described here, after they undergo some additional development. This type of planting would have a number of important advantages for small seeded row crops. A uniform, precisely spaced seedling emergence would be more nearly assured than for any cultural practice currently used. For example, if the weather were unseasonably warm, the field could be irrigated from corrugates during germination without danger of subsequent soil crusting over the seedlings. The holes would be stable even with moderate rain showers. Seedlings would be less subject to injury by the accumulation of salt at the surface. It might also be possible to apply higher herbicide rates to the soil above the seed for even better weed control than is presently available. The accumulation of

salt in the convex portion of the seed row might also help reduce weed germination (Bernstein et al 1955).

Several modifications should be considered for the prototype planters described here. Both should be modified to produce a convex seed row as shown in Fig. 5. Improvements in seed delivery are needed. It may be possible to develop a seed tape for the pneumatic punch planter to increase its ground-speed and improve the accuracy of seed placement. Seed fastened on a tape, could be rolled on a ratchet wheel so that a new seed was moved under the punch before each stroke. Because the seeds could be placed closely together, much less tape would be required than for those systems in which the tape is planted with the seeds. One might also consider a cone-shaped punch which would leave a funnel-type soil hole. The target for the seed would then be much larger (Fornstrom and McNamee, 1971), but the soil surface would need to be well stabilized. The stabilizing spray delivery line could be controlled by the hole punch timer so that each hole would be sprayed individually, reducing the amount of stabilizer used.

Seed delivery to the soil holes with the belt-type planter may be a problem under conditions where the belt creeps with respect to the soil surface. This might be overcome by designing a lower friction and higher traction belt, or it might be possible to develop a reliable vacuum seed delivery for this planter. If the punches on the front wheel were hollow and connected to a vacuum source, the tips of the punches could move through a seed chamber before entering the soil. The vacuum would then be turned off and pressure applied to release the seed at the bottom of the hole and to insure a clean punch when it returns to the seed chamber (Short and Huber 1970; Ul'yanov and Ivzhenko 1968).

The problem of belt creep might be overcome by supplying some drive to the sprocket wheels, or by making the

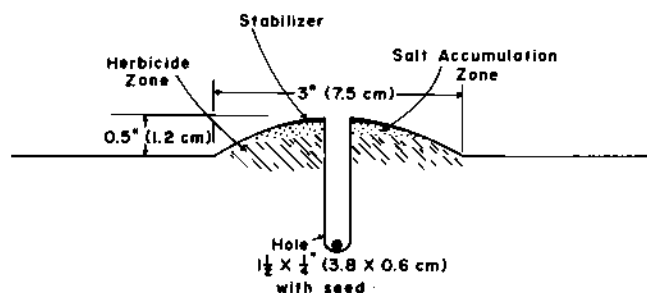


FIG. 5 Cross section of an ideal seed row for insuring an optimum stand of precision spaced small seeded plants.

unit self-propelled. On the other hand, the simplest solution may be to adjust the timing and location of the seed dropper so that the seed enters the eyelet immediately after the punch is removed.

It appears that the mechanical problems associated with autodibble planting can be solved. Because of its potential for establishing, under a wide range of weather conditions, a uniform, consistent, and precision planted small seeded row crop without hand labor, additional development and testing in a variety of

climates is needed.

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